

INDO-PACIFIC FISHERY COMMISSION

Report of the

INDO-PACIFIC FISHERY COMMISSION EXPERT CONSULTATION ON INLAND FISHERIES OF THE LARGER INDO-PACIFIC ISLANDS

Bangkok, Thailand, 4-9 August 1986

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PREPARATION OF THE DOCUMENT

This document is the final version of the report adopted on 9 April 1986 by the participants in the Expert Consultation on Inland Fisheries of the Larger Indo-Pacific Islands, Bangkok, Thailand, 4-9 August 1986. Country status reports and papers on special topics are issued as a Supplement to this Report.

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ABSTRACT

This document reviews the status of inland fisheries in eleven islands and/or island countries, i.e. Australia, Fiji, Guam, Hawaii, Indonesia, Madagascar, Mauritius, New Zealand, Papua New Guinea, the Philippines and Sri Lanka. Issues raised in the country reviews, special topic presentations and the following discussions are summarized under three major headings:

(1) Inland fishery resources development and management; (2) Socio-economic considerations; and (3) Planning for inland fisheries. Recommendations and suggestions are put forward for future activities for improvement in specific areas. Country status reports and papers on special topics are issued as a Supplement to this Report.

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RECOMMENDATIONS AND PROPOSALS FOR FUTURE ACTIVITIES
THE IPFC EXPERT CONSULTATION ON INLAND FISHERIES OF
THE LARGER INDO-PACIFIC ISLANDS
BANGKOK, THAILAND, 4-9 AUGUST 1986

The Expert Consultation recommended that:

1. Each country clearly identifies the indigenous species with potential for fisheries development and initiates studies on their biology, as well as limnological studies wherever necessary;
2. FAO supports a study to assess the status of the tilapia capture fisheries on the Indo-Pacific islands and mainland Asia;
3. a specialized meeting on the importance of estuaries for inland fisheries of the Indo-Pacific islands and Asia mainland be held in the near future;
4. FAO, in close collaboration with the individual countries of the Region, including mainland Asia, review the current use of irrigation and other canals for fishery, and identifies ways and techniques for enhancing the use of such canals for this purpose;
5. FAO organizes a special meeting on the significance of the common and Asian major carps for inland capture fisheries of the Indo-Pacific islands. Such a meeting should also consider interactions of carps and tilapias where representatives of both groups are stocked in the same water body;
6. collection and publication of inland water and aquaculture statistics from the Region be given full and immediate attention by the Information, Data and Statistics Service of the FAO Fisheries Department, with the following objectives:
 - (i) clear-cut definitions of "inland fisheries", "aquaculture", and "brackish waters", are needed to enable the separation of catches, landings and other statistical data;
 - (ii) sources of statistical data should be duly noted for each country;
 - (iii) the Service should agree with other data-gathering and publishing organizations in the area on unification of the data prior to its publication;
 - (iv) where applicable, the fact that subsistence fisheries is poorly recorded should be clearly stated in statistical yearbooks;
7. a similar consultation, including both the inland fisheries and aquaculture of the Indo-Pacific islands, be held in the future to assess progress in the individual fields of interest and to develop strategies for inland fisheries enhancement.

The Expert Consultation suggested that:

1. FAO Secretariat updates, in close collaboration with respective countries, the existing information on fish introductions to the Indo-Pacific islands;

2. FAO gives support to the preparation of yield prediction models for inland water management strategies;
3. FAO supports the preparation of a review of cost/benefit considerations on clearance of bush/trees prior to impounding new reservoirs on the Indo-Pacific islands and mainland Asia;
4. FAO assists as a clearing house for information and coordination of activities in the field of fish passage through rivers;
5. FAO organizes meetings on special areas of importance for inland fisheries of the Indo-Pacific islands, namely (i) on the significance of estuaries for inland fisheries, and (ii) on the significance of the common and Asian major carps for capture fisheries;
6. simple predator-prey systems in new water bodies of islands (e.g. Fiji) be closely monitored to provide much needed information for developing stocking strategies;
7. Dr. R.M. McDowall of New Zealand scrutinize the "EIFAC Code of Practice to reduce the risk of adverse effects arising from the introduction or transfer of inland aquatic organisms", and to determine its applicability in the Indo-Pacific Region.

The Expert Consultation also identified the need for:

1. analytical view of stocking practices hitherto adopted in the island countries, which would assist in making specific recommendations for stocking of the major types of existing water bodies;
2. clarification of the usefulness of stocking large perennial water bodies with non-self-propogating species, especially in view of the low returns of some such efforts;
3. assessing the economics of stocking reservoirs with larger-sized fingerlings in an effort to improve recovery rates in the face of high predation pressure;
4. individual countries to look into ways of reducing the cost of producing fingerlings for stocking lakes and reservoirs;
5. individual countries to assess the feasibility of utilization for various purposes of non-table-sized fish;
6. baseline investigations on the extent of hybridization amongst introduced cichlid stocks in Madagascar, Sri Lanka, Indonesia and the Philippines;
7. countries with developed recreational inland fisheries to legitimize recreational fishing activity as a non-consumptive user of water and to take into account its requirements;
8. ethnic and socio-cultural considerations in formulation of management strategies, especially in Papua New Guinea, Fiji and Guam, where conflicting attitudes may prevail as a result of the cross-cultural nature of their societies;
9. incorporation of fisheries considerations into the earliest stages of water and land resources development schemes, especially in those islands or island countries where a large number of reservoirs are planned for construction in the next decade, as in Sri Lanka and Indonesia.

REPORT OF THE IPFC EXPERT CONSULTATION
ON INLAND FISHERIES OF THE LARGER INDO-PACIFIC ISLANDS
BANGKOK, THAILAND, 4 - 9 AUGUST 1986

The Expert Consultation was convened from 4 to 9 August 1986 at the FAO Regional Office for Asia and the Pacific in Bangkok, Thailand. The organization of this expert consultation was based on a recommendation of the Second Session of the IPFC Working Party of Experts on Inland Fisheries, New Delhi, India, January 1984. Participants from eleven islands and island countries took part in this meeting, i.e. Australia, Fiji, Guam, Hawaii, Indonesia, Madagascar, Mauritius, New Zealand, Papua New Guinea, the Philippines and Sri Lanka.*

1. ORIGINS AND OBJECTIVES OF THE EXPERT CONSULTATION

The Second Session of the Working Party reconfirmed the need to increase the awareness of IPFC activities in the field of inland water fisheries among the countries of the Pacific. This idea has been broadened to include also major islands of the Indian Ocean, e.g. Madagascar and Sri Lanka, where a substantial number of multi-purpose reservoirs has been constructed, and with Madagascar's inland fishery ranking as the first among the islands in supplying fish for its population. The terms of reference of the Expert Consultation were: (i) to review the status of inland fisheries in the islands* concerned; (ii) to identify topics which require the most attention in study or management; (iii) to suggest activities needed for improvements in specific problem areas, including rehabilitation of the already existing fisheries.

Mr. V.L.C. Pietersz, Regional Fishery Officer, RAPA, Bangkok, welcomed the participants, and briefly outlined the history of the preparatory work for this meeting. He also informed the participants about the structure of IPFC and RAPA activities. RAPA provided the secretarial support for this meeting. Mr. H. Sakuda, Director, Hawaii Division of Aquatic Resources, USA, was unanimously elected Chairman of the Expert Consultation.

The first two days (4-5 August) of the meeting were devoted to presentation and discussion of country statements on inland fisheries. This was followed (6-8 August) by presentation and discussion of special topics related to the management of these fisheries. The Expert Consultation concluded by approval of the draft report.

Country reviews presented at this meeting have shown the great geographical, ethnic and developmental diversity of the countries represented at this meeting. This, in turn, was reflected in the diversity of their inland fisheries. The countries and islands extend between the southern temperate zone and the northern sub-tropics, and include populous countries such as Indonesia, Philippines, and Sri Lanka as well as countries with a low population density such as Australia and New Zealand.

The first group of countries pursues an active inland fisheries development policy aimed at increasing the fish protein supply for their people - a major concern in island countries with large human populations. The other group, in contrast, where the animal protein is readily available, has inland fisheries which serve largely recreational purposes. Thus, as could be expected, strategies for inland fisheries development and management differ widely between these two groups. In the intermediate group of largely smaller islands, a greater diversity of approaches is evident.

* For the purpose of this meeting, all countries present were considered as islands.

The reviews allowed the comparison of a number of technical and managerial aspects of inland fisheries. Issues raised during the country reviews, special topic presentations and the following discussions are summarized under three major headings: (1) Inland fishery resources development and management; (2) Socio-economic considerations; and (3) Planning for inland fisheries. Suggestions for future activities are included under the individual topics.

2. INLAND FISHERY RESOURCES DEVELOPMENT AND MANAGEMENT

A comparison of inland fish yield with that for marine fish illustrates the importance of inland fisheries to island countries. Among the ten island countries considered e.g. Australia, Fiji, Guam, Indonesia, Madagascar, Mauritius, New Zealand, Papua New Guinea, the Philippines and Sri Lanka, the contribution of inland fish yield to the total yield ranges from 0.23 percent for Mauritius, to 75.9% for Madagascar. The low values for Mauritius, New Zealand and Australia, with inland fish yields representing less than 3 percent of the total fish yield, show their high dependence on marine fish resources. In Madagascar and Papua New Guinea, freshwater fish contributes over 50 percent of the total yield, although the percentage in PNG yield depends on inclusion or exclusion of tuna. In most island countries, over the last six years the freshwater fisheries have been steadily expanding, with catches increasing markedly in Australia, Fiji, the Philippines and Sri Lanka. This indicates an increasing interest in and importance of inland water fisheries in many island countries of the Indo-Pacific, and reflects an increased commitment to the planning for and management of such resources.

2.1 Indigenous Fish Faunas

One of the features of many island nations represented on the Working Party, is that their indigenous faunas are of limited species diversity. The approximate number of species is highly variable with Indonesia having some 800 species, as contrasted with the large islands of New Zealand having only 27 species.

This is a product of factors such as geographical isolation, aridity, geological history and size, and in itself constrains the fisheries potential of such nations.

Despite this reduced diversity, knowledge of the fish faunas of some countries is incomplete and efforts should be made to adequately catalogue the faunas in such cases. The biology of most harvested species is not well known, which represents a constraint to the national management of resources. Riverine fishes in particular are poorly known. Even in the relatively few cases where indigenous species contribute to lacustrine fishery, e.g. Labeo dussumieri and Barbus sarana in Sri Lanka, Puntius gonionotus in Indonesia, the biology of these species is little known, while that of other lacustrine indigenous species with a potential for supporting reservoir fisheries is almost totally unknown. This lack of knowledge has in some cases induced countries to look for exotic species to establish fisheries in reservoirs and lakes often without proper and detailed assessment of the long-term impact of the latter on the flora and fauna. The potential fisheries value of lesser known species tends to be ignored or obscured, even though some may have considerable fisheries potential.

It is therefore recommended that each country clearly identifies the indigenous species with a potential for fisheries development and initiates studies on their biology. Such biological work should include limnological studies as environmental characteristics of inland waters are also inadequately known in many cases. FAO, if requested by a relevant governmental organization, could provide the necessary technical assistance.

Some countries have a large trade in aquarium fish, based on a variety of both freshwater and marine fish species. Although there is a tendency to exclude such species from considerations of inland fisheries, it was agreed that such species are a valuable resource and should be included and efforts should be made to upgrade knowledge of indigenous species suitable for the trade.

There are insufficient data on the status of fish stocks in most island countries to be aware of any case warranting endangered species status. This situation is unlikely to change without a considerable increase in the level of biological research, which may be difficult to justify in many cases.

2.2 Other Aquatic Resources

The dominance of inland catches by finfish in most countries, particularly in the case of lacustrine and reservoir fisheries, has tended to obscure the value of other aquatic resources. Particularly in subsistence fisheries, catches of bivalve molluscs (e.g. the freshwater mussel in Fiji), palaemonid (Macrobrachium, Palaemon) and atyid shrimps, crayfish, freshwater crabs, freshwater turtles and even crocodiles (e.g. PNG) may make sizable contributions to overall yields and should not be overlooked.

2.3 Aquatic Weeds

Aquatic weeds were noted to have impacted on inland fisheries in various ways.

A certain amount of floating macrophytes is considered beneficial for fish in some situations (e.g. in Indonesia reservoirs). In Sri Lanka, the current explosive growth of Salvinia molesta on Maduru Oya reservoir is possibly a temporary feature and may not warrant clearing efforts. The recent complete suppression of S. molesta on the Sepik river floodplains by biological control using the weevil Cyrtobagous salviniae has been followed by an increase in fishing activities, mainly for Oreochromis mossambicus. In Laguna de Bay in the Philippines, water hyacinth can restrict access to fishpens, and may cause fishpen destruction during typhoons, when piled up against the pens.

Where aquatic weed cover has been perceived as excessive, interfering with transport and fishing activity, exotic species, particularly grass carp, have often been introduced as a control measure. The effect of these introductions has generally proved beneficial for clearing the submersed and some emergent plants, but not effective against the major floating plants, such as Salvinia, Eichhornia and Pistia.

2.4 Stock Enhancement

A number of items were discussed under this heading: introductions, stocking and restocking in riverine and lacustrine environments, and use of pen and cage culture for increasing the fish yield from open waters, as well as related issues such as the performance of various species and strains of exotic species, predator-prey interactions, and genetic considerations underlying stock enhancement.

2.4.1 Introductions

Numerous introductions have been made in the eleven islands and island countries represented in the meeting with a view towards either increasing the fish protein supply (as in Fiji, Indonesia, Madagascar, Mauritius, PNG, the Philippines, and Sri Lanka), or to support the recreational fishing (as in Australia, Guam, Hawaii, Fiji and New Zealand). In the former case, while some significant improvements in terms of both nutrition and arti-

sanal catches have been recorded, the full benefit from fish introductions in Indonesia, Fiji, and Mauritius, has yet to be completely realized due to a poor knowledge of species interactions, their behaviour in new environments, and poor stocking practices, among others. Policies on fish introductions also remain undefined in some of the developing countries like Indonesia, Madagascar, Mauritius and the Philippines.

It was pointed out that introduced cichlids have successfully established themselves in a number of lakes and reservoirs in the Region. Their hybridization is beginning to cause certain problems in Madagascar, mainly relating to their reduced growth performance and the consequent detrimental effects on production, as a result of diminishing genetic diversity of the stock of these exotic species. Similar problems may occur elsewhere where closely related species are brought into sympatry.

It was further noted that there are differences among countries where the cichlids have successfully established themselves. In Sri Lanka, O. mossambicus supports a thriving reservoir capture fishery while O. niloticus has become dominant in the Philippines and Indonesia. In view of these apparent variations in species dominance and the corresponding importance given or emphases placed by the governments of the different countries within the region on the respective cichlid species, it was recommended that FAO support a study to assess the status of the tilapia fisheries on the Indo-Pacific islands and mainland Asia.

It was recognized that the attention paid to exotic species, particularly those in common use in other parts of the world, has resulted in a tendency to ignore or obscure the potential fisheries values of lesser known species with considerable value and potential from within the Region. Several islands have yet to develop a good understanding of the potential of fish resources from within their own waters. There is also a lack of wide appreciation among the islands as to the useful fish available within the Region.

Concern was raised as to the negative effects of introductions of exotics on some native stocks, observed for example in Lake Lanao (Philippines), Lake Kinneret (Israel), and Lake Victoria (Africa). The Expert Consultation stressed the need for a comprehensive list of all introductions into the big island countries, with notes on the biology of the introduced species and their apparent impacts on the environment and the indigenous species. The FAO Secretariat has been requested to update, in close collaboration with respective countries, the existing information on introductions.

It was further noted that in order to minimize the risks arising from such fish transfers, appropriate protocols, controls, and quarantine measures be established for the Indo-Pacific Region, similar to the EIFAC Code of Practice for Europe and North America. Dr. R.M. McDowall of New Zealand agreed to scrutinize the EIFAC Code of Practice to determine its applicability in the Indo-Pacific Region.

2.4.2 Stocking/restocking strategies

The yields from inland waterbodies in a number of countries in the Region have been substantially improved with stocking and restocking of fish species. Strategies for stocking differ from one country to another, however. For example whereas stocking programmes in Australia involve considerable use of native species like sea bass, golden perch, silver perch, and a variety of theraponids and eleotrids, Sri Lanka and the Philippines rely heavily on the exotic cichlids O. mossambicus and O. niloticus, respectively.

Stocking practices may also vary with the type of waterbody within the same country, as in Sri Lanka where the larger perennial reservoirs were stocked with O. mossambicus before the 1970s and later with the Chinese and Indian carps. In view of the wide diversity of stocking strategies in the Region, the participants expressed the need for an analytical view of stocking practices hitherto adopted in the inland countries, specifically Madagascar, Sri Lanka, Indonesia and the Philippines, with a view to making specific recommendations for stocking of the major types of existing waterbodies.

It was also noted that while the tilapias may be regarded as nuisance species in countries like the USA, Australia and New Zealand, they have high value as foodfish species for stocking lakes and reservoirs in the developing countries such as Indonesia, Madagascar, the Philippines and Sri Lanka.

There are other widely distributed indigenous species useful for stocking lakes and reservoirs, such as Kuhlia, Ophieleotris, Oxyleotris, Toxotes, Hemirhamphus, and various theraponids, the production potential of which has not been evaluated.

The meeting was informed that an inventory of species suitable for stocking in IPFC lakes and reservoirs, is currently being prepared by FAO and could be expanded to include the non-IPFC island countries in the Region. It was stressed that in order to determine the suitability of candidate species for stocking in lakes and reservoirs, studies on their biology and behaviour need to be conducted and the results made available to the different countries within the Region.

Emphasis was also laid on the importance of close collaboration and cooperation among the different countries of the Indo-Pacific, especially those within the same geographical sub-units (such as the Australasian group), on work pertaining to the potentially useful species which are common to their countries, and on which one country may have had previous experience.

Consultation among countries successful in the stocking of coldwater species is very important for species selection just as it is for stocking of suitable forage fish in waterbodies stocked with high-order carnivores.

The usefulness of stocking large perennial waterbodies with non-self-propagating species remains to be clarified, especially in view of the low returns of some such efforts. For example, an 8 000-ha Indonesian reservoir stocked within the last ten years with three tons of O. niloticus fry gave a low return of only 4.2 percent. Similarly, the repeated stocking of Chinese carps in the large perennial reservoirs in Sri Lanka gave little or no return.

The economics of stocking reservoirs with larger-sized fingerlings in an effort to improve recovery rates in the face of high predation pressure in such reservoirs, also needs to be assessed vis-a-vis the problem of limited availability of areas for nursing fry to fingerlings of sizes suitable for release in the reservoirs. It was noted that in Sri Lanka, for example, the high cost of producing fry of the Chinese and Indian major carps together with the low returns discourages their use in major reservoirs, and at the same time encourages the continued use of the tilapias which have successfully established themselves in the various reservoirs of the country. It should be pointed out that even though O. mossambicus is not deliberately stocked, it has successfully invaded some of the new reservoirs and continues to give encouraging results.

It was suggested that different countries look into ways of bringing down the costs of producing fingerlings for stocking lakes and reservoirs.

This can be done in different ways, such as improving the efficiency of hatchery techniques/methods and/or by using fry nurseries established in pen or floating cages which allow the use of higher stocking densities, as has been shown feasible in the Philippines with milkfish (*Chanos chanos*), in Thailand with seabass (*Lates calcarifer*), and in New Zealand with silver carp.

The maximum efficiency of utilization of such fry nurseries could only be attained, however, if sufficient quantities of fry are available at all times. It was noted that present problems arising from the seasonal shortage of milkfish fry in the Philippines could be alleviated once the induced breeding of milkfish is successfully adopted on a commercial scale, as in the case of Taiwan.

2.4.3 Riverine fisheries

Large tropical rivers have well established fish faunas and are generally considered a lower priority for stocking. The special case of the Sepik River in Papua New Guinea was, however, discussed. Here, due to geographical isolation, the indigenous fish fauna is even more depauperate than that of southern New Guinea and Australia where fish species diversity is already low.

Introductions of tilapia and more recently carp have significantly increased the fish yield and the possibility of further introductions, particularly to the lower order tributaries is being considered. Much baseline information remains to be collected to enable an appropriate risk-free stocking strategy to be formulated, but development needs are pressing in this situation and some compromise may ultimately have to be accommodated.

Australia and New Zealand both have important recreational fisheries. In tropical and most of inland Australia, these are based on a variety of indigenous species. The capability to stock many of these species from hatcheries has been developed to a considerable degree and some stocking of reservoirs is carried out. In temperate Australia and New Zealand, fisheries based on introduced salmonids are well developed and, in one case, (chinook salmon - New Zealand, east coast, South Island) a unique sea-run population has been established. Reductions of stocks of local species, exacerbated by habitat alteration, have been noted in some cases (e.g. New Zealand galaxiids).

The possibility of escaped exotic aquarium fishes establishing in rivers and having a negative impact on established stock was noted.

2.4.4 Lacustrine fisheries

Lakes and reservoirs in the Indo-Pacific islands and island countries exhibit a wide range of characteristics - from seasonal to perennial, from shallow, highly eutrophic to deep, oligotrophic, and from small (a few hectares) to very large (several thousand hectares). Physicochemical and biological features as well as fish fauna vary within each country and for the different countries within the Region.

Levels of utilization of the lacustrine fisheries also vary within each country and the Region, although most lakes have been traditionally utilized for open water fisheries. Average fish yields from these waterbodies vary, with a maximum of 3.5 mt/ha in the highly eutrophic Laguna de Bay in the Philippines, where such high yields have been attained from milkfish pens and tilapia cages without any need for supplemental or artificial feeding. On the other side of the scale are some natural lakes in Papua New Guinea, where fish fauna of same lakes is very limited and production minimal. In the Philippines, the use of aquaculture in the form

of fishpens and cages in lakes, to enhance fishery has developed in parallel with reductions in the rate of stocking and restocking, especially of milkfish. The role of introduced species, particularly milkfish, tilapia, and carp, in increasing yields from lacustrine fisheries as discussed in an earlier section was likewise noted, based on experiences in the Philippines, Sri Lanka and Indonesia.

2.4.5 Estuarine fisheries

On the Indo-Pacific islands, many estuaries are mangrove-lined and support important fisheries. In Hawaii, estuaries represent the major inland fishery being of a low priority user of this source. Fry gathering of fish such as milkfish and a number of other species is among the major fishery activities in estuaries of the Philippines, Mauritius and Indonesia. While the Philippines and Mauritius issue concessions for fry gathering in estuaries, other countries allow free entry. Detailed information on estuarine fisheries is lacking especially for Papua New Guinea, the Philippines and Madagascar. In New Zealand estuaries are recognized as being extremely important for reproduction and passage of freshwater fish and as major areas of fishing activities. The importance of estuarine mangroves for fisheries of most island countries represented was stressed and the meeting gave full support to the management strategies of the Workshop on Strategies for the Management of Fisheries and Aquaculture in Mangrove Ecosystems, held during the Third Session of the IPFC Working Party of Experts on Inland Fisheries, Bangkok, Thailand, 19-27 June 1986. Especially the management strategy number 6, which stresses the need to acquire comprehensive knowledge of the economic values of the intact system, has been emphasized.

The topic was recognized as being important and complex but essentially outside the brief of the present meeting. The Expert Consultation therefore recommended that a specialized meeting on the importance of estuaries for inland fisheries of the Indo-Pacific islands and Asian mainland be held in the near future.

2.4.6 Fisheries in irrigation and water distribution canals

Little use has been made of the islands' of canals for fish production. The exception is Indonesia, which has a long tradition of cage culture in some irrigation canals, although on a limited scale. In one situation, such cages have yielded 75 kg/m², with some supplementary feeding. The conflict between the uses of water for irrigation and fish production is frequently the major obstacle for establishing this type of fishery. Clearly, more work is needed in this field and the Expert Consultation therefore recommended that FAO, in close collaboration with the individual countries of the region, including mainland Asia, review the current use of irrigation and other canals for fishery, and identify ways and techniques for enhancing the use of such canals for this purpose.

2.4.7 Non-conventional fishery resources

In several developing island countries, the reservoir fisheries are confined mostly to larger table-size species, mostly exotic. The smaller varieties of fish present in reservoirs and lakes, which could constitute a valuable and significant resource, remain mostly unexploited. In Sri Lanka, for example, such resources could be used, if not for direct human consumption, for processing into fishmeal for the expanding aquaculture. Care should be taken, however, when developing the fishery for such resources so that its exploitation does not have a negative impact on conventional commercial fish.

Aquarium fish was discussed as another non-conventional fishery resource of considerable importance in Australia, Hawaii, Indonesia,

Mauritius and Sri Lanka. This resource is threatened, in some places, by overexploitation, as well as by deterioration of the aquatic environment due to pollution and rivershed manipulation. This resource should be considered a fishery and therefore managed on a sustained basis.

2.4.8 Comparative performance of important exotic species

While common carp is a fish of long tradition on most of the islands, tilapias are of more recent introduction. Both groups are exotics for all islands considered. The rapid proliferation of tilapia has lead to their absolute dominance of the Sri Lanka inland fishery where prior to their introduction in 1951, there was no commercial inland fishery in existence. Tilapias are the dominant commercial fish also in Madagascar, the Philippines and Papua New Guinea, and common in Indonesia. While in some countries they are listed as noxious fish (Australia, New Zealand), in some their eradication has been suggested (Nauru, Kiribati), and in other countries they are considered of poor value (Mauritius). However, it has been noted that fish eating habits can change, with tilapias in Sri Lanka, Indonesia and the Philippines now being widely accepted, and a trend towards their acceptance also being noted in Guam. The culture of red tilapia (hybrid and single strain) for higher priced markets is increasing. There may also be local variations in preference such as observed in the Philippines where the preference for tilapias and for the common carp varies between provinces. Common carp is now considered as of secondary importance in countries, where prior to introduction of tilapias, it was amongst the dominant fish. Little knowledge is available on the interaction of common and major Asian carps with tilapias where these are stocked into the same waterbodies. As the stocking of major carps is rather expensive, a comparative evaluation is also needed on the cost/benefit for these species, and on the rate of their catch recovery. The Expert Consultation therefore recommended that FAO organizes a special meeting on the significance of the common and Asian major carps for inland fisheries of the Indo-Pacific islands. Such a meeting should also consider interactions of carps and tilapias where representatives of both groups are stocked in the same waterbody. It was suggested that such a meeting should include specialists from the mainland Asia countries which have the best experience in this field. The meeting could be held as a workshop during the next combined session of the IPFC Working Party on Inland Fisheries and the IPFC Working Party on Aquaculture.

2.4.9 Predator-prey interactions and forage species

There is a tendency, especially when seeking species for the provision of recreational fisheries, to introduce predatory species. These tend to be larger and more active, and therefore have greater appeal to anglers.

Ecologically, such species have a greater propensity either to have serious impact on populations of small indigenous fishes that they exploit as forage fish, or to fail owing to lack of a suitable forage base.

A consequence of the above is that moves are then made to introduce forage fishes to support the top predator. The ecological consequences of these series of events can be profound and often unforeseen. Introduced forage species, for example, may in turn compete with such indigenous species.

When stocking the impoundments, a simplified ecosystem approach has been suggested, i.e., using predators and prey from the same ecosystem. Prediction of the outcome of such stockings is not yet possible and simple predator-prey systems (e.g. black bass - tilapia in the Vaturu reservoir, Fiji) should be closely monitored from the outset to provide much needed information on such systems.

It is clear that when stocking for food production purposes, omnivorous or herbivorous species, not necessarily large, are to be preferred over predators. Predators may have a role, in special cases, in reducing populations of undesirable forage species. Hitherto unused forage species present in Northern Australia could be considered for introduction within the Region.

2.4.10 Genetic considerations

Several genetic problems are evident in the fisheries of the Region. One is the maintenance of distinct and possibly valuable stocks in different geographical areas. Another is the tendency for prolonged hatchery rearing of stocks which results in loss of genetic diversity. The Expert Consultation gave full support to the need for maintaining genetic diversity in stocking material and stressed the need for baseline investigations on the extent of hybridization amongst introduced cichlid stocks in Madagascar, Sri Lanka, Indonesia and the Philippines.

2.5 Inland Fishery Yields

Among the island countries considered, the yield of inland fisheries is greatly variable, and depends on a number of factors, such as the overall aquatic productivity, fish stocks species composition, fisheries management intensity and resource manipulation, especially that affecting water quality and volume.

The best information on the yield from lacustrine environments is available for Indonesia, the Philippines and Sri Lanka, where inland fisheries are considered an important source of animal protein and hence inland fisheries management has been given considerable attention by the governments. Estimates of the actual and potential yields of lakes in Indonesia show that at present only one-third of the inland fisheries potential average yield of 57 kg/ha/yr is realized. Information on yields from marine fisheries are more difficult to obtain and therefore usually not available.

Open water fishery yield in a number of waterbodies in most inland countries has been enhanced by managerial measures, especially stocking and restocking, and by introducing pen and cage culture. In Laguna de Bay in the Philippines, pen and cage culture contributes now about 50 percent to the total yield from this natural lake. In the case of the Philippines, the application of these intensive techniques has resulted in a reduction in regular stocking of lakes and reservoirs which has been especially reflected in a decline in milkfish production from free waters.

2.5.1 Data collection and statistics

Some countries still do not have a fully developed and functional system for the collection of statistics on total landings from inland waters. Only commercial catch is usually recorded for publication in the FAO Yearbook of Fisheries Statistics (Catches and Landings), and may be based only on one or two species (e.g., seabass in Papua New Guinea, anguillid eels in New Zealand). In some countries where recreational fishing is the major activity, statistics, if available, may be of uncertain reliability (e.g., New Zealand), and are often completely excluded from catch figures. Subsistence inland fishery yields are also usually completely excluded from the reported data, even where they form the major inland fishery of the country (e.g., PNG). Countries where inland fisheries contribute little to the total fish yield (i.e., Mauritius, Guam, Hawaii) have limited, or even no, statistical data. The participants have recommended that collection and publication of inland water and aquaculture statistics from the Region be given full and immediate attention by the

Information, Data and Statistics Service of the FAO Fisheries Department, with the following objectives:

- i) Clear cut definitions of "inland fisheries", "aquaculture" and "brackish waters" are needed to enable the separation of catches, landings and other statistical data;
- ii) Sources of statistical data be duly noted for each country; if data are unreliable or incomplete, the government agency responsible for data provision should state this clearly, and this information should also appear in the official FAO statistics, as well as the basis of the data presented;
- iii) The Fisheries Statistics Division should liaise with other data-gathering and publishing organizations in the area, such as SEAFDEC, and agree on unification of the data prior to its publication;
- iv) Where applicable, the fact that subsistence fisheries is poorly recorded, be clearly stated in statistical yearbooks.

The above information should be disseminated by FAO to the Governments.

2.5.2 Predictive fish yield models

The scarcity of detailed reliable information on fish yields from inland waters of the larger Indo-Pacific islands is still the major obstacle to developing reliable predictive models. A typological approach to modelling is needed, which would take into account the diversity of waterbodies and fish stocks in the Region. The problem is acute especially for Sri Lanka, where a significant increase of new waterbodies is expected. Islands which already have reasonably sound data for a good number of inland waterbodies could attempt to formulate a predictive model, or if needed, several models for specific situations.

A unified fisheries management approach would speed up the development of a sound model by providing details on fish stock composition, fishery yield and fishing effort for a diversity of waterbodies. Such an approach would be feasible, for example, in Sri Lanka, where stocking seasonal fish tanks could yield a considerable amount of such information every year without the danger of one being left at the end of the experimentation with undesirable fish stock mix or fish species as would be the case in permanent waterbodies.

At present, at least three yield prediction models are needed, for each of the three major management strategies currently applied on the islands of the Indo-Pacific and in a number of countries of mainland Asia:

- i) Fisheries management of mixed endemic and exotic self-reproducing fish stocks (e.g. Indonesia);
- ii) Fisheries management of largely exotic self-reproducing fish stocks, e.g. tilapia;
- iii) Fisheries management of waterbodies dominated by non-reproducing stocks (e.g. Asian major carps, milkfish).

Another model appears to be needed on fishpen/fishcage application in lakes and reservoirs with different levels of aquatic biological productivity. The Expert Consultation strongly emphasized that FAO encourage and support preparation of such models.

The effectiveness of stocking for increasing fish yield in freshwaters needs to be carefully evaluated. For such evaluation, long-term data are

already available for some waterbodies of Indonesia and Sri Lanka, and for the mainland Asian countries of Thailand and India. India has perhaps the best data on the impact on fish yield of regular stocking with Indian major carps, while China could provide such information for the Chinese major carps. Results of such evaluation could be used for modelling, and for improvement of managerial strategies towards increasing fishery yield. Such data would also be invaluable for improved planning and economic considerations in a socio-economic context.

2.5.3 Fish eradication

On some small Pacific islands (e.g., Nauru, Kiribati) Oreochromis mossambicus present in ponds and lagoons is considered an undesirable species on account of competition with milkfish. Such countries have requested advice on its eradication which has not been achieved so far, owing to the large size of such undrainable waterbodies. The same species is also considered undesirable in Lake Toba, Indonesia, but no way has yet been found to destroy or even suppress this fish. The eradication of predatory fish such as Ophicephalus in Madagascar has also been unsuccessful, consistent with many similar unsuccessful attempts especially in Asia, where fish managers are losing part of the lacustrine yield to predators. The Expert Consultation noted the potential for controlling tilapias through the manipulation of nesting sites. It is, however, recognized that, at present, there are no universally effective measures available to deal with such situations.

3. SOCIO-ECONOMIC CONSIDERATIONS

Inland fisheries development and management operates against a background of diverse socio-economic factors which may present severe constraints in some cases. The Expert Consultation considered many of these; e.g., how emphasis in fisheries development varies according to the degree of economic development and population density, and how logistical factors affect development and sociological consequences of fisheries development.

3.1 Differing Fisheries Emphases within the Region

Nations with lower population densities and higher average standards of living tend to give higher emphasis to the recreational values inherent in the fisheries, e.g. Australia, New Zealand. The value of recreational fisheries in such cases may rival or even exceed that of commercial fisheries. Even on small islands (e.g., Hawaii, Guam) considerable effort has been expended to create recreational fisheries where limited natural waters and indigenous fauna previously existed.

More populous and generally less developed nations, are much more dependent on protein production from their freshwater fisheries and in such nations, the prime emphasis is towards subsistence fisheries, artisanal fisheries, major commercial fisheries and aquaculture production in fresh waters. Even in these countries, there have often been attempts to establish recreational fisheries, as in Madagascar, the Philippines and Sri Lanka.

Each country in effect represents a unique array of fisheries shaped by geographical, economic, historical and demographic factors and each must be considered in an individual context.

3.1.1 Subsistence fisheries

Subsistence fisheries are, in some nations, of profound importance to the provision of protein, especially where the population is spread into highly remote and inaccessible areas (e.g. PNG) and where there are few alternative protein sources (e.g. Fiji). While the productivity of eco-

systems supporting subsistence fisheries is rarely quantified and is seldom represented in fisheries yields reported from such nations, the local importance of such fisheries to the well-being of populations, needs to be placed in its proper perspective by planners and researchers to ensure that yields are sustained.

The question of ownership (traditional fishing rights) is often contentious and may particularly constrain attempts to increase production and promote movement into the cash economy as well as developments involving reservoir construction.

Traditional management regimes often have considerable value to resource management. It is not, however, desirable that full control of subsistence fisheries is vested in either traditional custodians or governments.

3.1.2 Recreational fisheries

Recreational fisheries similarly suffer from a lack of quantification (e.g., New Zealand, Australia) and this obscures the level of production of such fisheries leading to an underestimation of yields from those waters and their value. There is a need in such countries for planners to legitimize recreational fishing activity as a non-consumptive user of water and take a detailed account of its requirements. Environmental alteration frequently has a negative impact on recreational fisheries and necessary corrective measures are all too often not implemented, e.g. river redesign following dam construction and water diversion, fish passages, etc.

3.1.3 Transport, processing, marketing, quality control

Distance from landing sites to markets and the poor quality or absence of roads, increase the cost of fish and hinder development of commercial fisheries in some inland waterbodies (e.g., Papua New Guinea, Madagascar). Preservation and processing to prevent deterioration also increase production costs which may make the marketing of fish products impossible, unless a government subsidy is provided. If this does not happen, efficiently captured fish imported from larger fisheries may be substantially cheaper than the local product (PNG), and may act as a disincentive to the development of indigenous fisheries.

3.2 Sociological Aspects of Fisheries Development

The objectives of fisheries development are usually based on economic considerations (as in generation of income and livelihood opportunities) as well as on sociological factors like food preferences, local values and attitudes, and even cultural traditions.

It is not uncommon to hear about biases for or against certain fish species among the different countries in the Region. This has been highlighted by varying preferences for the tilapias and the different carps on the islands. As has been mentioned in an earlier section of this report, tilapia is largely preferred in Sri Lanka and the Philippines while there is a general dislike for it in Mauritius, New Zealand, Australia and the United States of America. It can even happen that preferences for certain fish species may be highly localized such that some may be more acceptable in some areas but not in others within the same country, as in the Philippines where local cyprinids are generally preferred in Mindanao but not in Luzon and Visayas.

The differing attitudes of people and their governments towards fish somehow determine the approaches to fish introduction and/or the enhancement of stocks by species diversification. The conservative attitude of people in adopting new food types as a substitute for, or in addition to,

traditional food, could hamper efforts to develop non-conventional, high-yielding aquatic resources for food.

Also, varying socio-economic needs may result in different orders of priority and corresponding management strategies in the countries within the Region. For example, whereas greater financial difficulties and heavier pressures to produce more fish for food somewhat indicate that governments of the developing countries (like Papua New Guinea, Indonesia and the Philippines) be more lax in the formulation and implementation of fisheries policies, the developed countries like the USA, Australia and New Zealand generally tend to be more rigid in their fisheries management policies and procedures.

It was also noted that ethnic and socio-cultural considerations should be used as bases for formulating management strategies, especially on the islands of Papua New Guinea, Fiji and Guam, where conflicting attitudes may prevail as a result of the cross-cultural nature of their societies.

4. PLANNING FOR INLAND FISHERIES

4.1 Multiple Use of Land and Water Resources and Inland Fisheries

The Expert Consultation recognized the multiple use of land and water resources on the islands and the various conflicts that arise from the shared use of these limited resources. It was noted that, of a whole variety of purposes of water resources development which include inter alia, irrigation, hydropower generation and water storage, the fisheries are usually relegated to a low priority, if ever at all. It was further noted that fisheries benefits arising from multi-use reservoir construction are hardly considered in planning stages of water resource development.

It was stressed that in spite of the limited success of efforts aimed at promoting fisheries interests in water and land resources development in the IPFC Region, government planners in the islands should be continuously made aware of the importance of the fisheries in the overall development schemes, and therefore of the need to incorporate fisheries considerations starting from the earliest stages of project planning and development. This is particularly essential where new reservoirs are planned.

Actual and potential benefits from man-made reservoirs in Fiji, Mauritius, Guam, Hawaii and New Zealand, where there were previously only limited freshwater fisheries resources, were recognized. However, it was stressed that fisheries management strategies would vary from one reservoir to another, depending on specific conditions of each reservoir, as well as on the country specifics.

The participants noted with concern the lack of available published information on the cost benefits of the clearance of bush/trees prior to impounding new reservoirs and suggested that a review of the subject be prepared for the Indo-Pacific Region similar to that done by Ploskey (FAO Fish.Tech.Pap.T258) for North America and Canadian impoundments.

The Expert Consultation also noted the shortage of trained technical people in the Region who would be capable of rendering advice to government planners on the fisheries aspects of water resource development. In this connection, it was mentioned that FAO holds an annual training course on planning for fisheries in river basin development under its Professional Training for Agricultural Development (PTAD) programme. In spite of the limited number of trainees the programme can accommodate, the course, which is open to individual applicants nominated by their respective governments, is nevertheless useful from the point of view of technical manpower development in the Region.

4.2 Impoundments and Fish Passage

The construction of impoundments for the management of riverine waters is a widespread practice for the storage and control of irrigation water and the generation of electricity on all the islands represented at the Expert Consultation. Impoundments have diverse impacts on riverine fisheries, as a result of the transformation of environments upstream of impoundments (from fluvial to lacustrine), the alteration of temperature regimes in rivers below dams, and the prevention of fish migration, among others. It was noted that the fluctuations of water levels within impoundments primarily used for irrigation or water storage could be extremely harmful to the fisheries, as has been the experience in a certain irrigation reservoir in Hawaii where massive fish mortalities occurred as a result of severe drawdowns. However, since these water level fluctuations are necessary management practices, measures should be taken, as far as possible, to minimize, if not totally prevent, such negative consequences on the fish stocks.

The Expert Consultation also recognized the importance of maintaining fish passage past impoundment, where necessary - both upstream and downstream - and therefore, of the need for the design of fish passage facilities at impoundments to allow passage. At present, the lack of knowledge on the migratory habits (time, season, etc.) as well as of behaviour and the capacity of species to move past barriers to migration, is a major constraint to the proper design and construction of such fish passages.

While great attention is customarily paid to upstream passage, the downstream passage of fish through impoundments (especially for hydroelectric dams where water flows through turbines) was recognized as a particular problem, as is the entrainment of downstream migrants when water is abstracted for irrigation.

Australia, in particular, has recognized the damage to riverine fisheries from the discharge of cool water from the depths of impoundments. In that country, fish species, whose spawning activities are triggered by highly specific temperature requirements, have undergone a serious decline in stocks. This is a problem that may be more widespread and unrecognized elsewhere. Careful impoundment design and attention to water management strategies can often mitigate such harmful impacts without compromising the values for which impoundments were constructed.

Problems of entrainment of fish during water abstraction for irrigation, provision of cooling waters to thermal power schemes, etc., are often difficult to solve, and attention is therefore needed in the design and installation of fish screens to exclude or divert fish from abstracted waters.

The Expert Consultation noted that current reviews of fish passages in Argentina and the Soviet Union have been commissioned by the Secretariat and could possibly be adapted to suit the specific needs of migratory fish species of the islands of the Indo-Pacific. It was also suggested that the following studies be undertaken in the Region:

- i) Migratory habits of important indigenous island fish species;
- ii) The ability of such species to move upstream past barriers of diverse types; and
- iii) Hydrological/engineering design of facilities to make them effective for fish passage.

The Expert Consultation requested the Secretariat to assist the island nations in this regard by acting as a clearing house for information and by

coordinating activities in this field. The Secretariat in turn requested the participants to assist in monitoring the demands and requests in their respective countries, and to keep the Secretariat informed of any developments in this field by way of correspondence or provision of reports, reprints, etc., on the topic.

5. CONCLUDING REMARKS

The Expert Consultation concluded with the following general observations:

- 1) The need for strengthening of contacts and for closer collaboration among the larger Indo-Pacific islands on a number of relevant issues, as raised during the Expert Consultation, was emphasized.
- 2) The need for more active liaison and collaboration among the island countries of the Indo-Pacific on one side, and between these countries and FAO on the other, was recognized. FAO has offered to act as a clearing house and coordinator of some activities. FAO, through selected consultants, can also initiate a limited number of review studies on selected topics.
- 3) The Expert Consultation recommended that a similar consultation be held in the future to review the progress in various fields of inland fisheries of the Indo-Pacific islands. Such a meeting should include aquaculture considerations.
- 4) Meetings on special areas of importance for inland fisheries of islands, such as of the significance of estuaries for inland fisheries, and a clarification of the significance of the common and Asian major carps in the inland fisheries of the Indo-Pacific islands and mainland Asia, should be held in the not-too-distant future.
- 5) The Expert Consultation gave full support to the activities of the IPFC Working Party of Experts on Inland Fisheries, and requested it to assist with the implementation of recommendations and suggestions as formulated by this Expert Consultation.

ANNEX A

AGENDA

4 August

Morning:

1. Opening of meeting
2. Eléction of Chairman
3. Adoption of Agenda and arrangements for Meeting
4. Country (Island) reviews: Australia

Afternoon:

4. Country (Island) reviews (contd): Fiji, Indonesia, Madagascar,
Papua New Guinea, Sri Lanka

5 August

Morning:

4. Country (Island) reviews (contd): Mauritius, New Zealand,
Philippines, Hawaii, Guam

Afternoon:

5. Special topics:

- Inland fishery yield of the major Indo-Pacific Islands (Petr)
- River fisheries and ways of enhancing them: a case study of the Sepik River, Papua New Guinea (Coates)
- Introductions and stocking of fish in lakes and reservoirs in Southeast Asian countries with special reference to Indonesia (Sarnita)

6 August

5. Special topics (contd):

- Production of stocking material in Australia (MacKinnon)
- Fish stocks for cool freshwater: a New Zealand perspective (McDowall)

Afternoon: Free

7 August

Morning:

5. Special topics (contd):

- Stocking practices in Sri Lanka (De Silva)

- Minimising the risk, protocols, controls and quarantine in fish introductions (McDowall)
- General discussion to introduction and stocking

Afternoon:

5. Special topics (contd.):

- Rehabilitation of the Masso reservoir fisheries to a recreationally fishing facility (Kami)
- Freshwater recreational fishing in Hawaii (Sakuda)

8 August

Morning:

5. Special topics (contd.):

- Estuarine fisheries (Sakuda)
- Planning for fisheries in new waterbodies (Baluyut)

Afternoon:

- Any other topics
- General discussion

9 August

- Report preparation
- Discussion and adoption of the Report

ANNEX B

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ANNEX C

BACKGROUND DOCUMENTS

1. FAO Fisheries Technical Papers

Baluyut, E.A., Stocking and introduction of fish in lakes and reservoirs in the ASEAN countries. FAO Fish.Tech.Pap., (236): 82 p.

Petr, T. (ed.), Inland fisheries in multi-purpose river basin planning and development in tropical Asian countries: three case studies. FAO Fish.Tech.Pap., (265):166 p.

2. FAO Fisheries Circulars

Baluyut, E.A., Assessment of problems in planning river basin development involving a hydroelectric scheme. FAO Fish.Circ., (756):38 p.

_____, Planning for inland fisheries under constraints from other uses of land and water resources: general considerations and the Philippines. FAO Fish.Circ., (798):44 p.

Cadwallader, P.L., A review of fish stocking in the larger reservoirs of Australia and New Zealand. FAO Fish.Circ., (757):38 p.

FAO, Inland fisheries of Indo-Pacific countries. FAO Fish.Circ., (794):59 p.

_____, A provisional list of inland fisheries and aquaculture specialists in the Indo-Pacific region. FAO Fish.Circ., (796):67 p.

3. FAO Fisheries Reports

Indo-Pacific Fishery Commission (IPFC), Report of the second session of the IPFC Working Party on inland fisheries. New Delhi, India, 23-27 January 1984, and Report of the Joint Workshop of the IPFC Working Party on inland fisheries and the IPFC Working Party on aquaculture, on the role of stocking and introductions in the improvement of production of lakes and reservoirs. New Delhi, 24-25 January 1985. FAO Fish.Rep., (312):56 p.

_____, Report of the third session of the Indo-Pacific Fishery Commission Working Party of Experts on inland fisheries. Bangkok, Thailand, 19-27 June 1986, and, Report of the Workshop on strategies for the management of fisheries and aquaculture in mangrove ecosystems. Bangkok, Thailand, 23-25 June 1986. FAO Fish.Rep., (370):42 p.

